Keynote Address: Knowledge as Wealth [1]

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The Institute of Medicine was pleased to join with the New York Academy of Medicine in presenting, in November 1995, a symposium devoted to urban health problems, and is again pleased to have the proceedings reported in this issue of the *Bulletin of the New York Academy of Medicine: a Journal of Urban Health.* The parallel interests of the Institute of Medicine and the New York Academy are expressed fittingly in the full title of the *Bulletin.* For all that they did to make the symposium a success, I thank Dr. Barondess and his colleagues, the planning committee, the New York Academy of Medicine for its co-sponsorship, and the Institute of Medicine's staff.

The Institute of Medicine has its origin in an 1863 Congressional act, signed by President Lincoln, to create the National Academy of Sciences as a private institution that would serve the federal government as an independent advisor on matters in science and technology as they relate to the national interest. Since its establishment in 1971, the Institute's mission has been to advance scientific knowledge and the health and well-being of all people of this nation and the world, consistent with its Congressional authority. It does that by publishing objective, timely, and authoritative information for the government, professions, and the public through both an elected membership and through access to the best expertise. The Institute is, then, part of the

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[1] Substantial portions of this presentation were derived from Dr. Shine's lecture as the Joseph Price Orator at the 1995 annual meeting of the American Gynecological and Obstetrical Society. The entire lecture will be published in the *American Journal of Obstetrics and Gynecology*, pages 1089–1093, April 1996.

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complex which includes the National Academy of Sciences, the National Research Council, and the National Academy of Engineering.

The Institute's membership is limited to 600 active members. At least a quarter of the members must be from fields other than health and medicine, which helps the Institute to bridge the gap between science and other aspects of society. Since 1988 we have had foreign associates, who have been important in terms of the Institute's effect on issues of international importance.

One-third of the Institute's work is initiated by the Institute itself. Although the Institute responds to government when asked, if one considers some of the Institute's salient projects and publications it is clear that we have often called attention to issues overlooked by many other institutions, including government. For example,"Confronting AIDS" was the landmark report which, in 1986, galvanized public policy in dealing with the AIDS problem, a problem that had previously been ignored. The Institute, funded by The Robert Wood Johnson Foundation, initiated the "Growing Up Tobacco Free" project, which was the basis for President Clinton's and the FDA's position on smoking and adolescence, announced in August 1995. "Emerging Infections" is an example of a project in which the Institute anticipated many of the difficulties with Hantavirus and resistant tuberculosis, and has served as the basis for the CDC's new policies with regard to surveillance. *The Future of Public Health* is a landmark report that is now a standard textbook in schools of public health. The Institute has not confined itself to publishing its findings in the scientific domain: for example, *Eat for Life* was an alternate selection of the Book-of-the-Month Club.

In all of its endeavors the Institute has acted on the premise that knowledge is the basic tool to be employed for the common good. I would like to share with you some thoughts with regard to knowledge and its function in our society.

Role of Knowledge in Society

For over three centuries, economists have measured the wealth of nations by three principal parameters—natural resources, population, and capital. Natural resources—the coal and the oil of the Middle East, the minerals of newly discovered North America—were a major determinant of a country's status in the world economy. But, as MIT professor Lester Thurow has pointed out, the dramatic decrease in the cost of shipping natural resources during the last half the twentieth century, the multiplicity of potential sources of energy, and the capacity of multinational corporations to produce in any location around the globe have reduced dramatically the relative impact of natural resources on an individual nation's economic standing.

With an increase in automation, globalization of production, and the capacity to use work forces in any part of the world, the size of any one nation's population no longer is a critical determinant of the wealth of that nation. The Persian Gulf War exemplified the way in which military technology has largely replaced the size of one's armies in determining the outcome of a conflict. When computer programs can be written by workers in India, when American insurance forms are processed in Ireland, when a clothing store can fill its racks just in time by telecommunication with production units in China and Taiwan, the work force of the world and the appetite of the consumer now are global.

So far as capital is concerned, the world watched as a currency crisis in Mexico unfolded at the end of 1994. In a matter of minutes, billions of dollars of investment capital were moved out of Mexico electronically by money managers in New York and Tokyo. The banks of the world watched carefully the election in Argentina with the knowledge that decisions about $6 billion in capital would be determined by the result of that election.

Natural resources, population, and capital no longer describe adequately the wealth of an individual nation. In the new world order, it is knowledge that will make the difference. If America and its urban centers are to maintain or improve their standards of

living, the health, safety, and prosperity of these entities will depend critically on how we generate and use knowledge. Let us consider the generation, dissemination, and use of knowledge as it applies to our society, to our urban centers, and to medicine and health in particular.

Few would argue that America's capacity to develop new knowledge has been unsurpassed. Whether by Nobel Prizes or leadership in the pharmaceutical, medical-device, communication, or space industries, these are knowledge-based American successes. Although there have been many reasons for those successes, three components deserve special emphasis.

First, the United States is unique in that it has created research universities. Our commitment to invest in fundamental science developed in institutions where both education and research occur simultaneously has produced not only outstanding science but also outstanding scientists. Despite Japan's many successes, the separation of research in its industrial segment, largely independent of its universities, has resulted in a Japanese scientific endeavor that is outstanding in applied technology but lacking in creativity.

In Germany the establishment of great research institutes independent of the universities is another commonly used model. Yet the American research university is pre-eminent and will continue to be so, as long as there is strong public support for the research enterprise in the university.

A second feature of the American success is the role of investigator-initiated peer-reviewed research, in which the creative instincts of our scientists find new questions and new opportunities. This method of acquiring new knowledge is quite different from the more centrally directed research activities in many other countries.

A third component has been the relative freedom of American science from direct political intrusions. One needs only to consider the development of Russian science to understand how the imposition of political doctrine on biology kept the quality of Soviet life sciences decades behind those of the United States. In contrast, Soviet expertise in such areas as physics and mathematics,

which were not inhibited by political doctrine, was among the best in the world until the economic collapse of the former Soviet Union.

In recent years we have seen the beginnings of such intrusion in the United States, in efforts to limit research in contraceptive, fetal, and behavioral activities. If these efforts continue, they promise dire consequences not only for advances in the fields directly involved but also for further intrusion of politics and ideology into science, which can only inhibit the development of important new knowledge.

That is not to say that in a time of limited resources it will not be important to set priorities and make choices regarding the investment in new knowledge. But these choices should be based on scientific opportunity and national science and technology needs, not on political or religious ideology. In a society where well over 40% of illnesses are the results of behavioral and environmental factors that are under our own control, our failure to carry out meaningful research in these areas is foolhardy.

Alcoholism, drug abuse, violence, smoking—note the attempt on the part of Congress to exclude the smoking program at the University of California, San Francisco from NIH support—accidents, environmental contamination, account for almost half of our national cost of health care. We must do effective research in these areas for the nation as a whole and particularly for our urban centers, which are plagued with many of these problems.

Both Japan and Germany spend a larger portion of their gross domestic product than does the United States on health-sciences research. Whereas all understand the need and desire to control the budget deficit, the last area in which Americans should reduce expenditures is that in which the investment is likely to produce knowledge that will yield better health and better jobs for Americans in the 21st century.

With the demise of the former Soviet Union, the United States has neither the Cold War nor Sputnik to stimulate us to invest in generating new scientific knowledge. Poverty, pollution, poor jobs, and disease, however, are as dangerous to America as the

Soviet Union was perceived to be; they should stimulate us to continue our investment in the generation of new knowledge.

As important as the generation of new knowledge may be, the appropriate, free, and open dissemination of that knowledge is also critical to a nation's success. Paul Kennedy, in *The Rise and Fall of Great Nations*, pointed out that both Japan and China were at relatively comparable stages of development with Europe in the year 1600. Japan's development was impeded dramatically by its decision to remain isolated from the rest of the world. In China, the decision to limit education to the Mandarin class and the failure to develop a way to disseminate information at a time when the Gutenberg press allowed the dissemination of information throughout Europe, changed the course of economic, social, and political history in that country.

In the face of world-wide work forces in which physical labor will be available at low cost, American workers can compete only if they are well prepared, with strong backgrounds in science and technology. Although there is no lack of Americans interested in going to medical school, the numbers of Americans matriculating in graduate science programs has not kept pace. The growing number of foreign graduate students in engineering and the physical and biological sciences has resulted not because they have displaced Americans from these programs but because of a failure to motivate young Americans to pursue such careers. Some of this failure may be attributed to a general decline in science literacy, to coin a phrase. General science literacy is critical not simply to produce scientists. It is absolutely essential if our work force is to be prepared to carry out responsibilities that will place them in a position of scientific and technological advantage over workers in other parts of the world.

Education of the Public

For all who are concerned with health, a scientifically literate population is crucial for several reasons. First, a scientifically literate patient and family is far better able to participate in

appropriate health-care decisions for themselves. One cannot discuss the risk of cigarette smoking or high blood pressure with a patient who does not understand the concept of risk. To discuss the probabilities associated with the outcomes of a behavior or a procedure with an individual or a group that does not understand probability will be fraught with disappointment.

Second, the capacity of populations, groups, and organizations to make informed decisions when purchasing health care or making decisions about health in their communities depends on an understanding of the scientific method, including risk and probability. The recent national attention to the death of five patients in a clinical trial of an anti-hepatitis drug conducted at the National Institutes of Health emphasizes these points. Those tragic deaths were the result of unanticipated complications of the drug. The Institute of Medicine, in fact, did a study of that process. In most cases the symptoms developed even after the drug had been stopped.

But clinical trials are performed for just this purpose, to try to understand in well-controlled circumstances what the risk and benefit of an intervention may be. Clinical trials are essential to progress and health and will always have an element of risk. Understanding the nature of such trials, the imperfection of our knowledge and understanding, and the fact that medicine can never guarantee outcomes any more than any other areas of science can achieve perfection, are important parts of scientific literacy. As providers of health care, we have a responsibility to help our patients in our communities to understand these concepts better.

Moreover, we also have a special interest in, and a responsibility to help improve, mathematics and science education in the schools, from the kindergarten level through the undergraduate college years. In autumn, 1995, the National Research Council published new national standards for science education. These standards do not tell teachers or school districts how to conduct their educational activities, but they do provide guidance with regard to what students ought to know. The standards for middle-

school students include major attention to human biology and reproduction and the impact of the environment on organisms, including the impact of such toxins as cigarette smoking and environmental contamination. Physicians and others who deliver health care should work within their own communities and institutions to help ensure that these science standards are adopted by local school boards, and should help implement the standards using inquiry-based, hands-on learning as opposed to the boring, historically rote learning characteristic of American education in science. It is appalling that young people can graduate from some of our greatest universities, including institutions in New York City, without ever taking a single course in science.

Without some understanding of the scientific method, its limitations and opportunities, members of our society not only will be unable to contribute adequately to the future of the economy, they are also going to be skeptical about the nation's investment in science and will be reluctant, at a time when resources are scarce, to choose that investment over shorter-term goals and gratifications.

The Institute will be sponsoring a 5-day program in the middle of 1997, in which we will invite 20 academic health centers around the country to come, with representatives of their local school departments, to learn about the standards and also to learn about hands-on learning, so that they might try to engage their faculties in the process of introducing these procedures into the local school districts where they work. Our faculties are out there working, but they are not doing it in a way that produces systemic change in education.

Scientific literacy is absolutely critical to our health-care systems. Well-informed, joint patient-doctor decision-making provides the pivotal methodology to control the cost of health care, improve public health, and keep both medicine and public health in the control of patients and providers rather than insurers and administrators.

The power of information and education is remarkable. In a recent Institute of Medicine study on the role of women in

sub-Saharan Africa, we observed once again that the education of women is the single most powerful force in the control of population. Education not only provides knowledge with regard to reproductive choices, but also is empowering and is critically important to change the relationship between men and women so that women can participate forcefully and effectively in decisions about their own fertility and childbearing.

Knowledge is power. In the area of population control there is no more powerful contraceptive than an educated woman.

Knowledge and the Private-Public Balance

Knowledge forms the basis of intellectual property. If the wealth of nations is to be predicated largely upon the development of new knowledge, it is important that efforts in this regard are rewarded by properly applied patent policy that protects the innovator from others who would exploit her or his hard-earned knowledge, and provides adequate compensation.

When a product is well defined, its utility well known, and the invention a real innovation, patents are useful. At the same time, the free and rapid diffusion of knowledge among scientists and around the world is required to allow science to move forward rapidly. Attempts to patent bits of information without understanding their use—for example, the debate over gene sequences —is counterproductive, both to science and to industry. If the recovery of investment in the development of a new product requires negotiation with scores of patent holders, each of whom has rights to bits and pieces of the process, investment in new products will be inhibited. If the use of information in the laboratory requires licensing concessions by each investigator who uses that information, the long-term result will be confusion, which will benefit lawyers far more than it will improve health.

Health sciences have been particularly successful in translating new products into production through venture-capital companies, biotechnology firms, mature pharmaceutical developers, and the device industry. These collaborations are essential, but those who

engage in them must always be cognizant and protective of the strength of our research-university enterprise, which has been built upon the free exchange of information among investigators and students.

The continued rapid explosion of new knowledge relevant to the practice of medicine emphasizes the necessity for educating physicians to be prepared to ask the appropriate questions and to learn where and how to obtain the relevant information as it is needed. For the information-literate people in our society, particularly those who use such devices as the Internet or World Wide Web, more and more information about health will be available, more and more rapidly. The individual physician will be confronted increasingly by questions from individuals who have already looked up information on the Web and who have obtained a substantial amount of data from these sources. Increasingly, the physician's response will have to be, "Give me a moment to look that up," rather than to profess absolute knowledge and authority about every subject.

New Knowledge

This brings us to the specific challenge of developing new knowledge and its application in health care and in making decisions about health. Regardless of which precise form the health-care system takes, certain phenomena are inevitable. These include increasing consolidation of health-care systems, whether through market, government, or regulatory forces, an emphasis on integrated multidisciplinary health-care provider teams, of which the physician is a pivotal but not the sole member (and in many cases not the most important member), and the continuing conflict between the public interest and controlling the rate of rise of health-care costs while expanding access to care in our population.

By the end of the decade, I anticipate that between 70 and 80% of all health care in most metropolitan areas will be provided by between two and six networks of providers. By that time, almost all Medicare services, Medicaid programs, and the majority of care

for the medically indigent in most communities will be in some form of managed-care network. Profit margins for the for-profits will plummet to a few percent as the industry matures, and the conflict between controls of cost and maintenance of quality will be exacerbated further. Ultimately, I believe the industry will become regulated, with oversight by an entity not unlike the Public Utilities Commission. In the interim there will be considerable pain and misadventure.

Although the initial discussion of outcomes research and allusions to report cards were met with considerable skepticism and even opposition by physicians, I would submit that knowledge of outcomes, like the education of women, is empowering and will be critical to the maintenance of quality in our health-care system.

The quintessential feature of a successful system will be a well-informed, joint patient-doctor decision-making process. By a well-informed phy ·ian I mean one who has adequate access to data about alternate therapies, about the state of health of the patients for whom he or she is responsible, and about choices between prevention, treatment, and rehabilitation. Until recently we have practiced medicine using science and technology. The new paradigm will require that the practice itself be more scientific, even as it recognizes that art will always be required.

The importance of knowledge can be appreciated by a few examples. In New York State, initial collection of data about operative mortality from bypass surgery revealed a remarkable range of operative mortality, one about which both physicians and patients were unaware. The highest mortality was in small-volume surgical programs. Once this information became available, not only the public but the trustees of the hospitals in which these programs went on were anxious to see change, and almost all of the small-volume operations ceased. In Pennsylvania, which did a similar study, none of the surgeons with high mortalities were doing cardiac surgery 18 months later, at least not in Pennsylvania. In New York there are no longer any facilities at which fewer than 200 cardiac surgeries per year are performed.

As a cardiologist, I have helped families to make decisions about

removing patients from life-support systems when those patients were not legally dead but when the probabilities were fully understood by the family and all those concerned. Having been involved in scores of such decisions, I have never been the subject of a malpractice suit or any litigation relating to these decisions. The reason, of course, is that we had established adequate and meaningful communication with patients who were informed and who participated in the appropriate decision. The nurses and the staff of the units were also involved in this information.

In the paradigm that I am describing, "patients" refers to individual patients, groups of patients in a practice or a health-care system, communities, states, or other groups of citizens. By "doctor" I mean providers of health care, including health-care systems. Just as an individual patient and physician can make a well-informed judgment, so these decisions ought to be reached in managed-care organizations by discussions between patients and providers.

Although it has many problems, the Oregon health plan represents an experiment in which significant numbers of citizens participated in the decision about services that would be provided. Patients frequently are considerably more conservative than their physicians and often choose less-aggressive rather than more-aggressive approaches if they are fully informed. I would suggest that this kind of joint decision-making, based on full information, is the best initial method of avoiding rationing of health-care services.

Although it is true that there are always patients who will demand that everything be done, I was impressed as recently as 2 months ago, during my last rotation as an attending physician on general medicine, with the ability of people to make informed choices about treatment of terminally or demented parents after they had been fully informed. We had a number of situations in which children had been demanding aggressive interventions, one after another, in the care of a demented parent without previously having the benefit of a sympathetic, well-informed discussion, and

often they recognized that it was better for their parent if we did not pursue those aggressive options.

To the extent that data confirm that an expensive and a highly specialized treatment would be beneficial, the role of recipients of care and their providers in making these decisions is critical if administrators and insurance companies ought to be kept out of the decision-making process. I believe that every managed-care organization ought to be required to have a standing appeals committee, consisting of two or three individuals within the system and two or three public members, to whom providers or patients could appeal any decision with regard to the availability of care. I would argue that the availability of this mechanism, combined with an information-based decision making process, would do much to enhance the rational use of resources while maintaining quality.

In summary then, the future of America depends on its wealth. Knowledge will be the major determinant of that wealth. In our great urban centers, such as New York City, the generation of new knowledge, of both the fundamental and applied nature, is important to the economic viability of the community. It requires the support and maintenance of our great research universities and excellent communication between fundamental science and its application in industry, with adequate protection for intellectual property. It also requires that there be free and open communication among scientists and between scientists and their students, and that there be no political or ideological control over the nature of the science that is pursued. It requires that intellectual property for which there is a well-defined utility receive patent protection; after all, that is producing wealth. But there also must be rapid and open access to new technology when such technology is important as a research tool.

We all have an interest in raising the level of science literacy, including science and technology education in our public schools and in our undergraduate curriculum. This can be no more important than in our major urban centers, in which, in many cases, the level of this education is under enormous pressure and is totally

inadequate to prepare our students for careers in science, or to make science-literate contributions to society. A science-literate population results in a more effective work force, a society that will support the financial investment in science and technology, the generation of new knowledge, and, most importantly, the empowerment of our citizens so that they can make decisions about personal health, public health, community health, and so that they can expand their horizons with regard to the utility of knowledge in applying it to the community and to the individual.

As health care is reorganized, as is happening so rapidly in New York City and elsewhere, knowledge will be critical for providers and consumers. Knowledge about the individual's health and the health of the community is essential if the providers, the public health organizations, the patients and the community are to make rational decisions involving many of the economic, ethical, and quality issues that we confront.

Making major decisions about services for individuals, groups of patients, and the community through dialogues between the recipients of services, whether they are preventive or therapeutic, and the providers of those services, is critical. Whereas consolidation of health-care systems will continue, it is also critical that we strengthen our capacity to measure quality, to monitor it, to compare quality of services from one group of providers to another, and to balance the problems of quality, cost, and access by involving the recipients of health-related services in the decision-making process, and to include all members of our society as recipients of high-quality care.

In maintaining our public health capacity and in maintaining personal health, all have a major stake in the overall knowledge status of our society. To the extent that knowledge is enhanced and enriched, it not only creates a better world in which we live, but it also enhances our capacity to serve.